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VARIATION IN THE CHEMICAL COMPOSITION OF SOILS.

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INTRODUCTION.

In a previous paper [1] complete analyses of a number of important American soils were presented and discussed chiefly from the point of view of the occurrence of rare elements seldom sought in soils. In that paper, although the analyses were presented under soil-type names and classified by soil provinces, the data were not considered sufficient to warrant any discussion of the chemical variation of soil types or of soil provinces.

Since then, analyses of additional samples, for major constituents only, have been made, and it has seemed that these, together with those already published, might furnish a basis for some general discussion of the variation in chemical composition of American soils.

The additional data, given for the first time in the present paper, include the results of the analysis of 45 samples, representing 18 distinct soil types, distributed in 4 soil provinces. The samples come from 22 different localities in 8 States, and were taken with extreme care by men familiar with the various soils under field conditions.

DESCRIPTION OF SOILS ANALYZED.

The soil-type names, location, character of samples, and short description of the soils follow:

1. Colorado sand. T. 5 N., R. 65 W. Near Greeley, Col. Soil, depth 0 to 14 inches. This type consists of old stream-borne material derived from the harder

[1] U. S. Dept. Agr. Bul. No. 122 (1914).

rocks of the Rocky Mountains and deposited over extensive foot slopes, modified in places by residual material from underlying sandstone. It is adapted to fruit and truck crops where not too loose and subject to leaching. The spot where this sample was taken had been cultivated, but supported only weeds at the time the sampling was done. Heavy crops of oats and alfalfa were growing on near-by fields. The sample is typical.

2. Colorado sand, subsoil of No. 1, depth 14 to 36 inches.

3. Oswego silt loam. Two miles northwest of Manhattan, Kans. Depth 0 to 14 inches. This is a dark-gray soil occupying level to gently rolling upland prairies. It is of residual origin and derived from shale, with occasional interbedded layers of sandstone or limestone and in places outcrops of bituminous coal. This sample was taken from a woodlot about 40 years old that had never been in cultivation. The productiveness of this type is fair.

4. Oswego silt loam. Subsoil of No. 3. Depth 14 to 36 inches.

5. Knox silt loam. T. 52 N., R. 34 W., 2 miles north of Farley, Mo. Depth 0 to 14 inches. This soil is formed from wind-deposited glacial material. It occupies rolling to hilly areas which originally supported a hardwood timber growth. The sample was taken on a high bluff from a field supporting a fair growth of clover. This type produces good yields of wheat, corn, clover, and grass.

6. Knox silt loam. Subsoil of No. 5. Depth 14 to 36 inches.

7. Memphis silt loam. Five miles southwest of Granada, Miss. Depth 0 to 6 inches. This type occupies uplands and is subject to serious erosion. It is a productive soil.

8. Memphis silt loam. Subsoil of No. 7. Depth 6 to 36 inches.

9. Memphis silt loam, smooth phase. Five miles northwest of Granada, Miss. There is very little difference between this soil and No. 7, except the difference in topography indicated by the name. This sample is a shade lighter than the typical. The subsoil is the same as that of typical specimens. The locality would indicate the close relationship between the soils. The productivity is good.

10. Memphis silt loam, smooth phase. Subsoil of No. 9. Depth 6 to 36 inches.

11. Cahaba fine sandy loam. Three miles northwest of Fort Gaines, Ga. Depth 0 to 12 inches. This type is alluvial in origin and occupies the older and higher terraces along the larger streams in the Coastal Plain of the Gulf States. It is a very important agricultural soil. The sample is typical, with the exception that the soil is somewhat too brown and the subsoil is nearly as red as the Orangeburg.

12. Cahaba fine sandy loam. Subsoil of No. 11. Depth 12 to 36 inches.

13. Cahaba very fine sandy loam. Minden, La. Depth 0 to 12 inches. This soil is formed in the same way as the Cahaba fine sandy loam, and except for its finer texture has the same characteristics. Soil and subsoil are typical.

14. Cahaba very fine sandy loam. Subsoil of No. 13. Depth 12 to 36 inches.

15. Norfolk sand. Near Montrose, S. C. Depth 0 to 8 inches. This type is formed from worked-over material coming from the higher-lying provinces. It is not possible to trace its origin to any particular rock or formation. This type is not productive except when heavily fertilized. The sample analyzed was typical as regards the soil, but the subsoil was not so yellow as the typical subsoil.

16. Norfolk sand. Subsoil of No. 15. Depth 8 to 36 inches.

17. Orangeburg sand. One mile east of Day School, Terrell County, Ga. Depth 0 to 10 inches. This type is formed from the worked-over material of the higher provinces. Its reddish color is characteristic. The subsoil is a reddish sand underlain at a depth of 3 feet or more by a reddish sandy clay. It is not productive, except where it is well fertilized. The sample is typical.

18. Orangeburg sand. Subsoil of No. 17. Depth 10 to 36 inches.

19. Orangeburg sandy loam. Two miles east of Fort Gaines, Ga. Depth 0 to 12 inches. The type consists of a medium grayish brown to reddish-brown sand or light sandy loam, from 4 to 5 inches deep, resting on a red sandy clay subsoil usually

containing small gravel and iron concretions. It is of moderate productiveness, but needs applications of complete fertilizer to give the best results. The sample analyzed was typical. There were iron concretions in this sample having well-polished surfaces.

20. Orangeburg sandy loam. Subsoil of No. 19. Depth 12 to 36 inches.

21. Greenville sandy loam. Two miles east of Fort Gaines, Ga. Depth 0 to 10 inches. The soil consists of a reddish-brown medium sandy loam, with a brick-red sticky sand to sandy loam subsoil, becoming heavier with depth. It is of sedimentary origin and derived from unconsolidated deposits of the Coastal Plain. This soil is one of the most productive soils of the upland Coastal Plain region. The sample analyzed was typical. There were in this sample iron concretions of about the same size and abundance as in the Orangeburg sandy loam. The surfaces of these concretions, however, were rough, inclosing soil grains on the surface, which indicates that the process of formation is still going on, or that the concretions in the Orangeburg sample had been polished by water action since their formation.

22. Greenville sandy loam. Subsoil of No. 21. Depth 10 to 36 inches.

23. Norfolk fine sandy loam. One mile north of Elza, Ga. Depth 0 to 10 inches. This is a pale-yellow to gray fine sandy loam, underlain by a yellow fine sandy loam which grades into a light sandy clay at an average depth of 18 inches. It is derived from reworked material carried from the higher-lying soil provinces. This soil is of moderate productiveness. The sample analyzed was typical, except that the subsoil was more brownish red than yellow.

24. Norfolk fine sandy loam. Subsoil of No. 23. Depth 10 to 36 inches.

25. Norfolk fine sandy loam. Three miles southwest of Murphy, Ga. Depth 0 to 16 inches. The general description given for No. 23 applies equally well to this sample. The soil is somewhat too brown and the subsoil more brown than yellow, otherwise the sample is typical.

26. Norfolk fine sandy loam. Subsoil of Sample No. 25. Depth 10 to 36 inches.

27. Tifton fine sandy loam. One and three-fourths miles northeast of Bellville, Ga. Depth 0 to 12 inches. This type consists of a gray or yellowish-gray medium sandy loam, overlying an ocherous-yellow, heavier and more compact medium sandy loam. Both soil and subsoil contain iron concretions and the type is known as pimply land. The type is derived from unconsolidated Coastal Plain deposits. The Tifton soils are somewhat more productive than the Norfolk soils. The sample analyzed is typical, except for a slightly redder shade in the subsoil.

28. Tifton fine sandy loam. Subsoil of No. 27. Depth 12 to 36 inches.

29. Ruston fine sandy loam. One mile south of Minden, La. Depth 0 to 6 inches. The soil of this type is a light-gray or yellowish-gray fine sandy loam, underlain by a buff or reddish-yellow, somewhat mottled heavy fine sandy loam or sandy clay. The type is derived from unconsolidated sediments of the Eocene period modified by an admixture of Lafayette material. The productiveness is low. Both soil and subsoil are typical.

30. Ruston fine sandy loam. Subsoil of No. 29. Depth 6 to 36 inches.

31. Ruston fine sandy loam. One and one-fourth miles northeast of Bluffton, Ga. Depth 0 to 10 inches. The description given for No. 29 applies to this sample, which, however, approaches the Orangeburg in color characteristics, the soil being browner and the subsoil redder than normal. Otherwise the sample is typical.

32. Ruston fine sandy loam. Subsoil of No. 31. Depth 10 to 36 inches.

33. Susquehanna fine sandy loam. Two and one-half miles north of courthouse, Smith County, Tex. Depth 0 to 12 inches. The soil is a gray to brown fine sand or light fine sandy loam, resting on a red or yellowish clay, which is usually stiff and plastic and mottled in the lower depths. Iron concretions are found throughout the soil profile. The type has been derived principally from the underlying clays. It is rated as of medium productivity. The soil and subsoil are typical.

34. Susquehanna fine sandy loam. Subsoil of No. 33. Depth 12 to 36 inches.

35. Susquehanna fine sandy loam. Eight miles northeast of Shubuta, Miss. Depth 0 to 10 inches. The description of No. 33 applies to this sample. Both soil and subsoil are typical.

36. Susquehanna fine sandy loam. Subsoil of No. 35. Depth 10 to 36 inches.

37. Susquehanna fine sandy loam. Four miles south of Hartsfield, Ga. Depth 0 to 12 inches. The description of No. 33 also applies to this sample. The subsoil does not seem to be as highly plastic as the average of the type; otherwise the sample is typical.

38. Susquehanna fine sandy loam. Subsoil of No. 37. Depth 12 to 36 inches.

39. Portsmouth fine sandy loam. Two miles south of Murphy, Ga. Depth 0 to 12 inches. This is a black to rusty-brown, mucky, fine sandy loam, compact and heavy when wet. Large quantities of organic matter in all stages of decomposition are present. The type is formed from the worked-over material of the higher-lying provinces. When drainage conditions are favorable, the fertility is fair. The soil and subsoil are typical.

40. Portsmouth fine sandy loam. Subsoil of No. 39. Depth 12 to 36 inches.

41. Susquehanna clay. Three miles east of Shubuta, Miss. Depth 0 to 4 inches. The soil of this type is a clay loam, sometimes containing gravel, and the subsoil a stiff, tenacious, red and mottled clay. It is formed from unconsolidated deposits of the Coastal Plain. The soil is very refractory and hard to cultivate and at present has very little agricultural value. The sample, both soil and subsoil, are typical.

42. Susquehanna clay. Subsoil of No. 41. Depth 4 to 36 inches.

43. Coxville fine sandy loam. Florence, S. C. Depth 0 to 8 inches. The soil of this type consists of a gray to dark-gray moderately heavy fine sandy loam overlying a stiff, rather plastic clay, which ranges in color from yellow in the upper part to mottled yellow, drab, and bright red in the lower section. Small iron concretions and quartz gravel are sometimes encountered in both soil and subsoil. In productivity it is only fair. This soil is derived from unconsolidated deposits of the Coastal Plain province.

44. Coxville fine sandy loam. Subsoil of No. 43. Depth 8 to 16 inches.

45. Coxville fine sandy loam. Lower subsoil of No. 43. Depth 16 to 36 inches.

PREPARATION OF SAMPLES AND METHODS OF ANALYSIS.

The preparation of the samples for analysis was essentially that described in the previous report [1] and the methods of analysis were those used in the analysis of silicate rocks followed in the previous work, and described in detail by Hildebrand.[2]

In carrying on this work the authors gave considerable attention to the limits of error in the more important determinations involved in soil analysis, and lest too much significance be attached to small differences they feel warranted in making the following statement. When working on the same sample of a soil of average composition the determinations of two analysts who have had experience with the methods used should not differ more than 0.50 per cent in the case of SiO_2, 0.05 in the case of TiO_2, 0.20 Al_2O_3, 0.15 Fe_2O_3, 0.003 MnO, 0.10 CaO, 0.15 MgO, 0.05 K_2O, 0.05 Na_2O, and 0.04 P_2O_5, these figures being percentage of soil, not percentage variation. Duplicates by the same analyst should of course agree more closely. Variations in the solubility of glassware were found to be a most frequent source of disagreement in CaO and MgO determination.

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[1] U. S. Dept. Agr. Bul. No. 122 (1914). [2] U. S. Geol. Survey Bul. 422 (1910).

The method used for determining phosphorus was tested on synthetic mixtures, and as a result it is estimated that the figures given for phosphoric acid are within 0.02 per cent of the actual amount present.

Blank determinations were made in all cases, and the silica and magnesia corrected for impurities. The quantity of silica in the iron and alumina group precipitate had been found constantly so small in earlier work that no correction was made for it here.

RESULTS OF ANALYSES.

The results of these analyses are given in the following table. The results are stated in percentage of the soil dried at 105° C.

Table 1.—*Chemical analyses of certain American soils.*

[Analyses by W. O. Robinson and L. A. Steinkoenig; nitrogen determinations by Wm. H. Fry.]

Constituent.	Great Plains Province.				Glacial and Loessial Province.					
	Colorado sand.		Oswego silt loam.		Knox silt loam.		Memphis silt loam.		Memphis silt loam, smooth phase.	
	(1) 0–14 inches.	(2) 14–36 inches.	(3) 0–14 inches.	(4) 14–36 inches.	(5) 0–14 inches.	(6) 14–36 inches.	(7) 0–6 inches.	(8) 6–36 inches.	(9) 0–6 inches.	(10) 6–36 inches.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
SiO_2	78.85	76.84	71.38	68.74	76.81	75.95	81.13	73.58	80.78	72.67
TiO_2	0.32	0.36	0.68	0.70	0.70	0.70	0.78	0.80	0.86	0.79
Al_2O_3	9.68	11.09	12.29	14.45	9.73	11.16	8.52	12.25	8.48	12.80
Fe_2O_3	2.72	3.21	3.63	5.00	3.26	3.99	2.92	5.02	3.05	5.58
MnO	0.031	0.036	0.056	0.057	0.068	0.067	0.027	0.067	0.036	0.052
CaO	0.94	1.08	1.09	0.88	0.92	0.92	0.31	0.36	0.27	0.26
MgO	0.72	0.62	0.36	1.12	0.60	0.74	0.39	0.78	0.45	0.84
K_2O	2.31	2.57	2.28	2.20	2.10	1.60	1.78	2.14	1.84	2.08
Na_2O	2.02	2.06	1.14	1.12	1.74	1.74	0.52	0.71	0.72	0.56
P_2O_5	0.11	0.09	0.10	0.08	0.12	0.10	0.08	0.14	0.10	0.13
SO_3	0.07	0.20	0.12	0.18	0.11	0.02	0.03	0.02	0.03	0.04
N	0.10	0.07	0.20	0.13	0.14	0.06	0.11	0.07	0.06	0.05
Loss on ignition	2.28	2.35	7.11	5.49	4.09	2.77	3.40	4.01	3.20	3.96

Constituent.	River Flood Plains Province.				Coastal Plain Province.							
	Cahaba fine sandy loam.		Cahaba very fine sandy loam.		Norfolk sand.		Orangeburg sand.		Orangeburg sandy loam.		Greenville sandy loam.	
	(11) 0-12 inches.	(12) 12–36 inches.	(13) 0–12 inches.	(14) 12–36 inches.	(15) 0–8 inches.	(16) 8–36 inches.	(17) 0–10 inches.	(18) 10–36 inches.	(19) 0–12 inches.	(20) 12–36 inches.	(21) 0–10 inches.	(22) 10–36 inches.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
SiO_2	91.39	73.25	93.29	91.83	94.81	97.01	96.18	91.86	94.32	77.20	92.42	73.03
TiO_2	0.52	0.69	0.42	0.46	0.51	0.53	0.35	0.41	0.40	0.66	0.41	0.70
Al_2O_3	3.72	13.79	2.45	3.83	1.42	1.31	1.70	4.11	2.13	12.75	2.78	16.11
Fe_2O_3	0.97	4.88	0.78	1.19	0.60	0.52	0.59	1.32	0.85	3.18	1.55	5.11
MnO	0.065	0.024	0.066	0.079	0.028	0.005	0.016	0.011	0.054	0.027	0.030	0.016
CaO	0.21	0.15	0.15	0.12	0.19	0.03	0.08	0.05	0.05	0.09	0.01	0.10
MgO	0.09	0.34	0.01	0.09	0.01	0.01	Trace.	Trace.	Trace.	0.08	Trace.	0.23
K_2O	0.90	1.08	0.45	0.58	0.08	0.08	0.08	0.10	0.10	0.14	0.13	0.14
Na_2O	0.12	0.10	0.03	0.05	0.12	0.08	Trace.	Trace.	0.29	0.20	0.26	0.26
P_2O_5	0.06	0.05	0.06	0.05	0.10	0.03	0.04	0.04	0.05	0.08	0.05	0.06
SO_3	0.06	0.05	0.10	0.13	0.08	0.06	0.07	0.10	0.07	0.11	0.02	0.05
N	0.05	0.10	0.05	0.03	0.05	0.02	0.06	0.02	0.03	0.08	0.02	0.03
Loss on ignition	1.53	5.18	2.12	1.61	2.33	0.79	1.03	1.75	1.69	5.19	2.00	5.46

TABLE 1.—*Chemical analyses of certain American soils*—Continued.

Constituent.	Coastal Plain Province—Continued.											
	Norfolk fine sandy loam.		Norfolk fine sandy loam.		Tifton fine sandy loam.		Ruston fine sandy loam.		Ruston fine sandy loam.		Susquehanna fine sandy loam.	
	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)
	0–10 inches.	10–36 inches.	0–16 inches.	16–36 inches.	0–12 inches.	12–36 inches.	0–6 inches.	6–36 inches.	0–10 inches.	10–36 inches.	0–12 inches.	12–36 inches.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
SiO_2	95.54	90.60	92.87	89.04	94.15	76.29	95.51	85.95	90.22	74.80	90.90	67.55
TiO_2	} 1.70	5.57	0.43	0.55	0.41	0.78	0.36	0.60	} 4.26	15.40	0.57	0.82
Al_2O_3			2.75	5.36	1.67	12.51	1.70	6.75			2.59	16.08
Fe_2O_3	0.62	1.19	1.17	2.04	0.94	4.01	0.68	2.65	1.52	4.09	3.02	7.52
MnO	0.020	0.007	0.007	0.003	0.026	0.006	0.017	0.008	0.020	0.009	0.024	0.008
CaO	0.06	0.03	0.03	0.01	0.05	0.07	0.12	0.12	0.06	0.02	0.11	0.16
MgO	Trace.	0.04	Trace.	0.07	Trace.	0.15	Trace.	0.18	0.01	0.04	0.09	0.60
K_2O	0.06	0.12	0.05	0.10	0.10	0.12	0.16	0.36	0.12	0.08	0.28	0.66
Na_2O	0.18	0.14	0.01	Trace.	Trace.	Trace.	0.04	0.04	0.14	0.10	Trace.	Trace.
P_2O_5	0.05	0.04	0.04	0.03	0.04	0.05	0.04	0.05	0.05	0.07	0.04	0.05
SO_3	0.03	0.04	0.05	0.06	0.06	0.07	0.23	0.13	0.04	0.05	0.07	0.05
N	0.06	0.02	0.04	0.05	0.04	0.04	0.07	0.03	0.05	0.03	0.08	0.05
Loss on ignition	1.94	2.37	2.35	2.55	2.31	5.78	1.49	3.15	3.59	5.71	2.21	6.75

Constituent.	Coastal Plain Province—Concluded.										
	Susquehanna fine sandy loam.		Susquehanna fine sandy loam.		Portsmouth fine sandy loam.		Susquehanna clay.		Coxville fine sandy loam.		
	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)
	0–10 inches.	10–36 inches.	0–12 inches.	12–36 inches.	0–12 inches.	12–36 inches.	0–4 inches.	4–36 inches.	0–8 inches.	8–16 inches.	16–36 inches.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
SiO_2	91.37	67.47	91.17	75.04	94.85	94.61	76.67	62.07	92.92	92.81	80.63
TiO_2	} 2.78	0.73	0.42	0.82	0.56	0.56	1.02	1.00	0.84	0.96	1.16
Al_2O_3		14.88	3.65	13.38	1.37	2.97	8.98	18.45	1.19	3.65	11.03
Fe_2O_3	3.00	9.43	1.31	5.04	0.41	0.33	6.05	8.42	0.58	0.77	2.61
MnO	0.013	0.006	0.008	0.007	0.003	0.002	0.097	0.013	0.010	0.005	0.005
CaO	0.04	0.10	Trace.	Trace.	Trace.	Trace.	0.40	0.37	0.05	0.08	0.08
MgO	0.03	0.52	Trace.	Trace.	Trace.	Trace.	0.32	0.67	0.01	0.01	Trace.
K_2O	0.10	0.46	0.12	0.16	0.06	0.02	0.56	0.76	0.08	0.06	0.08
Na_2O	0.12	Trace.	Trace.	0.01	0.06	0.02	0.01	0.02	0.12	0.06	0.14
P_2O_5	0.09	0.10	0.04	0.10	0.05	0.06	0.06	0.05	0.04	0.03	0.04
SO_3	0.08	0.07	0.08	0.04	0.03	0.03	0.04	0.05	0.05	0.05	0.07
N	0.03	0.03	0.05	0.01	0.05	0.03	0.07	0.05	0.08	0.02	0.07
Loss on ignition	2.26	6.17	3.11	5.31	2.26	1.61	5.42	8.09	4.46	1.63	4.36

The previously published data, to which reference has already been made, and which it is proposed to discuss in connection with the analyses presented in the foregoing table, comprise the analyses of twenty-four samples, representing twelve soil types distributed in four soil provinces.

The results of these analyses, for major constituents only, are presented in Table 2.

TABLE 2.—*Chemical analyses of certain American soils.*

[Analyses by W. O. Robinson.]

Province and type.	Depth.	Constituent.								
		SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
Coastal Plain:										
Norfolk sandy loam—	*Inches.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Soil	0–14	94.50	2.07	0.83	0.39	0.09	0.10	0.11	0.06	0.07
Subsoil	14–36	85.30	8.82	1.91	.38	.19	.12	.07	.04	.13
Limestone Valleys:										
Decatur clay loam—										
Soil	0– 4	79.35	8.89	4.44	.63	.39	.67	.24	.18	.13
Subsoil	4–15	74.81	12.80	5.28	.40	.33	.75	.16	.15	.19
Hagerstown loam—										
Soil	0– 8	70.99	11.39	4.23	.93	1.08	2.71	.82	.19	.34
Subsoil	8–24	66.49	14.80	5.99	.35	1.93	3.58	.66	.16	.14
Glacial and Loessial:										
Volusia silt loam—										
Soil	0– 8	75.12	10.49	4.13	.49	.48	1.40	.90	.18	.09
Subsoil	8–36	74.64	12.26	5.01	.37	.90	1.99	.99	.15	.10
Marshall silt loam—										
Soil	0–15	75.61	9.67	3.54	1.08	.77	2.28	1.03	.22	.17
Subsoil	15–36	71.43	13.44	4.28	1.40	1.28	2.03	.63	.16	.14
Gloucester stony loam—										
Soil	0– 8	65.68	14.15	5.67	1.36	.83	2.16	1.39	.15	.17
Subsoil	8–36	73.80	13.24	4.37	1.19	.39	2.22	1.75	.11	.03
Piedmont Plateau:										
Cecil clay—										
Soil	0– 6	66.49	17.11	7.43	.36	.31	.62	.16	.17	.07
Subsoil	6–36	44.15	27.58	16.23	.44	.09	.61	.15	.15	.07
Cecil sandy loam—										
Soil	0– 8	88.57	5.76	1.55	.39	.21	.82	.16	.08	.04
Subsoil	8–36	55.69	24.42	8.83	.40	.29	1.06	.14	.07	.09
Durham sandy loam—										
Soil	0–10	80.79	10.55	1.61	.89	.19	3.96	.87	.12	.06
Subsoil	10–36	69.35	18.04	3.42	.72	.29	3.34	.89	.12	.06
York silt loam—										
Soil	0–10	76.71	12.85	2.81	.08	.29	3.26	.39	.05	.12
Subsoil	10–22	74.38	16.31	2.56	.21	.38	4.07	.30	.05	.14
Louisa loam—										
Soil	0–12	84.58	5.54	3.30	.21	.25	.74	.14	.12	.15
Subsoil	12–30	74.99	10.90	6.75	.26	.32	.97	.28	.15	.16
Penn silt loam—										
Soil	0– 9	74.33	11.00	4.64	1.13	.69	1.57	1.53	.16	.15
Subsoil	9–24	71.76	14.36	5.82	1.73	1.06	1.50	1.54	.10	.10

PETROGRAPHIC EXAMINATION.

In the samples analyzed a search was made by the petrographic method for the presence of the more important soil minerals. Those sought for and their formulas are:

Quartz=SiO_2.
Magnetite=Fe_3O_4.
Orthoclase=$KAlSi_3O_8$.
Microcline=$KAlSi_3O_8$.
Biotite=About $(H, K)_2(Mg,Fe)_2Al_2Si_3O_{12}$.
Muscovite=About $H_2KAl_3Si_3O_{12}$.
Plagioclase=Isomorphous mixtures of $NaAlSi_3O_8$ and $CaAl_2Si_2O_8$.
Hornblende=Chiefly $Ca(Mg, Fe)_3Si_4O_{12}$ with $Na_2Al_2Si_4O_{12}$ and $(Mg, Fe)_2(Al, Fe)_4Si_2O_{12}$.
Epidote=$HCa_2(Al, Fe)_3Si_3O_{13}$.
Titanite=$CaTiSiO_5$.
Garnet=$\ddot{R}_3\dddot{R}_2(SiO_4)_3$ in which $\ddot{R}$ is Ca, Mg, Fe, and Mn, and $\dddot{R}$ is Al, Fe, and Cr, and rarely Ti.
Apatite=$(CaF)\ Ca_4P_3O_{12}$. F may be replaced by Cl.
Zoisite=$Ca_2\ (AlOH)\ Al_2\ (SiO_4)_3$.
Cordierite=$H_2(Mg, Fe)_4Al_8Si_{10}O_{37}$.
Chlorite=Probably a mixture of $H_4(Mg,Fe)_3Si_2O_9$ and $H_4(Mg,Fe)_2Al_2SiO_9$.
Cyanite=Al_2SiO_5.
Sillimanite=Al_2SiO_5.
Tourmaline=A complex silicate of B and Al, with Mg, Fe, or the alkali metals prominent.
Rutile=TiO_2.
Zircon=$ZrSiO_4$.

This search, it should be understood, involved an examination of a reasonable number of subsamples and the expenditure of a reasonable time, the results being relative rather than absolute. Experience in this work supports the conclusion that by extending the search indefinitely, nearly all the minerals sought would be found in traces in most soils.

The results of the petrographic examination are presented in Table 3. In this table P. indicates that the mineral is plentiful, S. present in small amounts, VS. in very small amounts, T. in traces. A plus (+) or minus (−) sign after a letter has the usual significance.

The petrographic method as at present developed throws no light on the mineral character of soil material finer than silt, and as a consequence not only does it fail to give any information regarding the chemical character of that portion of the soil that probably is most reactive chemically, but may give rise to apparent discrepancies when the petrographic data are compared with the results of chemical analysis.

TABLE 3.—*Mineralogical analyses of soils for which chemical analyses are given in Table 1.*

[Petrographic examination by Wm. H. Fry.]

Province and type.	Quartz.	Magnetite.	Orthoclase.	Microcline.	Biotite.	Muscovite.	Indetermi-nato micas.	Plagioclase.	Hornblende.	Epidote.	Titanite.	Cyanite.	Sillimanite.	Tourmaline.	Rutile.	Zircon.
Great Plains province:																
Colorado sand, 0–14	P.	T.	P.	S.	VS.	VS.	....	P.	S.	....	....	....	....	....	T.	....
14–36	P.	T.	P.	S.	VS.	VS.	....	P.	S.	T.	....	....	....	....	T.	....
Oswego silt loam, 0–14	P.	T.	P.	T.	....	VS.	....	VS.	VS.	VS.	T.	....	....	....	VS.	....
14–36	P.	T.	P.	....	....	VS.	....	VS.	VS.	T.	....	....	....	....	VS.	T.
Glacial and Loessial province:																
Knox silt loam, 0–14	P.	T.	S.	T.	T.	S.	....	T.	T.	VS.	....	....	....	....	VS.	T.
14–36	P.	T.	S.	T.	T.	VS.	....	T.	T.	T.	T.	....	....	....	T.	T.
Memphis silt loam, 0– 6	P.	T.	S+	....	S.	VS.	....	VS.	VS.	VS.	T.	....	....	T.	VS.	....
6–36	P.	T.	S.	....	T.	S+	....	....	VS.	T.	T.	....	....	T.	VS.	....
Memphis silt loam, 0– 6	P.	T.	S.	....	VS.	VS.	....	T.	T.	T.	T.	....	....	T.	VS.	....
6–36	P.	T.	S.	....	VS.	S.	....	T.	....	T.	....	....	....	T.	VS.	....
River Flood Plains province:																
Cahaba fine sandy loam, 0–12.	P.	T.	VS.	T.	....	VS.	....	T.	T.	T.	....	....	T.	....	T.	T.
12–36.	P.	T.	VS.	T.	....	VS.	....	T–	....	T–	....	....	T.	T.	VS.	T.
Cahaba fine sandy loam, 0–12.	P.	T.	VS.	T–	....	T.	....	T.	?	....	....	....	....	T.	T.	T.
12–36.	P.	T.	VS.	....	....	T.	....	T.	T–	....	....	....	....	T.	T.	T.
Coastal Plain province:																
Susquehanna clay, 0– 4	P.	T+	T.	....	....	T.	....	....	....	....	....	T.	....	T.	VS.	T.
4–36	P.	T.	T.	....	....	T.	....	....	....	....	....	....	....	T.	VS.	T.
Coxville fine sandy loam, 0– 8.	P.	T–	....	....	....	....	....	....	....	....	....	T.	....	T.	T.	T.
8–16.	P.	T–	....	....	....	....	....	....	....	....	....	T.	....	T.	T.	T.
16–36.	P.	T–	....	....	....	....	....	....	....	....	....	....	....	T.	T.	T.
Norfolk sand, 0– 8	P.	T.	....	....	T.	....	....	....	....	....	....	....	....	T.	T.	T.
8–36	P.	T–	....	....	T.	....	....	....	....	....	....	T.	....	T.	T.	....
Orangeburg sand, 0–10	P.	T–	....	....	....	....	....	....	....	....	....	....	VS.	T.	T.	T.
10–36	P.	T–	....	....	....	....	....	....	....	....	....	....	T.	T.	T.	T.
Orangeburg sandy loam, 0–12.	P.	T.	....	....	....	....	....	....	....	....	....	....	....	T.	T.	T.
12–36.	P.	T.	....	....	....	....	....	....	....	....	....	....	T.	T.	T.	T.
Greenville sandy loam, 0–10.	P.	T.	T.	....	....	....	....	....	....	....	....	....	T.	T.	T.	....
10–36.	P.	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Norfolk fine sandy loam, 0–10.	P.	T–	....	....	....	....	....	....	T.	....	....	....	....	....	T.	T.
10–36.	P.	T–	....	....	....	....	....	....	T.	....	....	....	....	T.	T.	T.
Norfolk fine sandy loam, 0–16.	P.	T–	....	....	....	....	T.	....	....	T.	....	....	....	....	VS.	T.
16–36.	P.	T–	....	....	....	....	....	....	....	....	....	....	....	....	VS.	T.
Tifton fine sandy loam, 0–12. .	P.	T.	....	....	....	T.	....	....	T.	....	....	....	....	T.	T.	T.
12–36. .	P.	T.	....	....	....	....	....	....	T.	....	T.	....	....	T.	T.	T.
Ruston fine sandy loam, 0– 6.	P.	T.	T.	....	....	T.	....	....	T.	....	....	....	....	T.	T.	T.
6–10.	P.	T.	T.	....	....	T.	....	....	T.	....	....	....	....	T.	T.	T.
Ruston fine sandy loam, 0–10.	P.	T.	....	....	....	....	....	....	....	....	....	....	....	T.	T.	T.
10–36.	P.	T–	....	....	....	T.	....	....	....	....	....	....	....	T.	T.	T.
Susquehanna fine sandy loam, 0–12	P.	T.	T.	....	....	T.	....	....	T.	....	....	....	....	T.	T.	T.
12–36	P.	T.	....	....	....	VS.	....	....	....	....	....	....	....	T.	T.	T.
Susquehanna fine sandy loam, 0–10	P.	T.	T.	....	....	T.	....	T–	....	....	....	T–	....	T.	T.	T.
10–36	P.	T–	T+	....	....	....	....	....	....	....	....	....	....	T.	T.	T–
Susquehanna fine sandy loam, 0–12	P.	T.	T.	....	....	....	....	....	....	T–	....	T.	....	T.	T.	T.
12–36	P.	T.	....	....	....	....	T.	....	....	....	....	....	....	....	T.	....
Portsmouth fine sandy loam, 0–12	P.	T–	....	....	....	....	....	....	....	....	....	....	T.	....	T.	T.
12–36	P.	T–	....	....	....	....	....	....	....	....	....	....	T.	T.	T.	T.

In addition to the minerals mentioned in the table, a few others were sought but found once or twice only. These were: Garnet, a trace only, in the subsoil of Knox silt loam; apatite, a trace only, in the Cahaba very fine sandy loam; zoisite, a trace, found in soil of Knox silt loam, and the lower subsoil of Coxville fine sandy loam; cordierite indicated but not conclusive in subsoil of Greenville sandy loam; and chlorite, a trace, found in the subsoil of Susquehanna clay.

DISCUSSION OF DATA.

Preliminary to any discussion of these data it should be observed that they are still too meager to warrant conclusions regarding many

phases of soil composition concerning which it is extremely desirable to reach conclusions, but with this limitation in mind it is thought that the following topics may be discussed from the point of view of chemical composition: Relation of soil to subsoil; extreme variation in composition; variation in soils of the same province; variation in soils of the same type; and the relation of the limit of error in analysis to quantities of constituents.

RELATION OF SOIL TO SUBSOIL.

It has been commonly observed that where there is a distinct subsoil, differing in color and texture from the surface soil, there may be a marked difference in the chemical composition of the two and that this difference is most marked in the content of silica, iron, and alumina. Usually it is found that the silica is higher in the surface soil and the iron and alumina in the subsoil.

The analyses presented here are in accord with this experience. Thirty-four locations are represented by soil and subsoil, and in all but two cases the silica is higher in the surface soil. The iron is higher in the subsoil in all but five cases, and the alumina in all but one.

Allowing a limit of error for all determinations of 0.05 per cent and regarding all figures that do not differ by more than 0.05 as equal, the relations of soil to subsoil in composition are summarized in Table 4.

In this table are stated the number of locations where soil and subsoil are the same in composition with regard to any constituent and the number of locations where they were found to differ by amounts of 0.05 to 0.5, 0.5 to 1, and more than 1 per cent.

TABLE 4.—*Comparison of soils and subsoils, as regards chemical composition.*

Group.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
Soil higher, more than 1 per cent	28	1	....	....	....	....	....	....	....
Soil higher, 0.5 to 1 per cent	3	....	....	....	....	....	....	....	....
Soil higher, 0.05 to 0.5 per cent	1	4	1	8	3	5	7	3	5
Soil and subsoil equal	....	....	....	19	7	12	22	29	24
Subsoil higher, 0.05 to 0.5 per cent	....	....	....	6	21	16	5	2	5
Subsoil higher, 0.5 to 1 per cent	....	11	1	1	3	1	....	....	....
Subsoil higher, more than 1 per cent	2	18	32	....	....	....	....	....	....

EXTREME VARIATION.

The soils analyzed represent a wide variation in kind of material from which they have been derived, processes of formation, topography, and present climatic conditions, and probably represent for some of the constituents nearly the extremes in composition of soils in this country.

The extremes in composition with regard to major constituents are as follows:

	Per cent.
Silica, SiO_2	97.01 to 44.15
Iron, Fe_2O_3	16.23 to 0.33
Alumina, Al_2O_3	27.58 to 1.19
Potash, K_2O	4.07 to 0.02
Soda, Na_2O	2.06 to 0.01
Lime, CaO	1.73 to 0.01
Magnesia, MgO	1.93 to 0.01
Phosphoric acid, P_2O_5	0.22 to 0.03
Sulphuric acid, SO_3	0.34 to 0.02

There were 9 samples in which there were but traces (less than 0.01 per cent) of soda, 13 with but traces of magnesia, and 4 with but traces of lime.

In discussing the extreme variation shown in the samples analyzed the authors wish to avail themselves of general information they have regarding soil composition, based on partial analyses of other samples not here reported, and hold to the following opinion:

The maximum and minimum figures for silica, iron, and alumina stated above, while probably not the maximum or minimum of soils of the United States, are probably nearly so, and soils exceeding this maximum or not reaching this minimum in content of these constituents are not often met, except in the case of quartz sands on the one hand and muck soils on the other.

With regard to potash the same statement applies, although to a less extent. No soils have been encountered in these laboratories having less than 0.01 per cent K_2O, and while there are soils containing more than 5.0 per cent K_2O they are not common.

Less is known regarding the true maximum and minimum of soda content, for the reason that so few soils have been completely analyzed and there are few available data for this constituent. It is probable that in humid regions the maximum soda content of soils is considerably less than that of potash, and instances where but traces are present are not uncommon.

The results for lime and magnesia, while representing the minimum, are far from the maximum. Soils derived from calcareous material and as yet unleached may, of course, be very high in both lime and magnesia content, but even where there is little or no carbonate present the total content of lime and magnesia may each be above 5 per cent.

The figures for phosphoric acid do not represent the maximum or minimum. It is not uncommon to encounter soils containing 0.01 per cent, and soils containing as high as 0.8 per cent are often found, although generally confined to small areas.

The knowledge of the total sulphur content of soils is not extensive enough to make any general statement regarding the maximum and minimum content.

VARIATION IN THE SAME PROVINCE.

The variation in composition of soils from the same soil province, soil and subsoil stated separately, is shown in Table 5:

TABLE 5.—*Variation in chemical composition of soils from the same province, soils and subsoils shown separately.*

Province and sample.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Great Plains:									
Soil	78.85–71.38	3.63–2.72	12.29– 9.68	1.09–0.94	0.72–0.36	2.31–2.28	2.02–1.14	0.11–0.10	0.12–0.07
Subsoil	76.84–68.74	5.00–3.21	14.45–11.09	1.08– .88	1.12– .62	2.57–2.20	2.06–1.12	.09– .08	.20– .18
Glacial and Loessial:									
Soil	81.13–65.68	5.67–2.92	14.15– 8.48	1.40– .27	.83– .39	2.28–1.40	1.74– .52	.22– .08	.17– .03
Subsoil	75.95–71.43	5.58–3.99	13.44–11.56	1.19– .26	1.28– .39	2.22–1.60	1.74– .56	.16– .10	.14– .03
River Flood Plains:									
Soil	93.29–91.39	.97– .78	3.72– 2.45	.21– .15	.09– .01	.90– .45	.12– .03	.06– .06	.10– .06
Subsoil	91.83–73.25	4.88–1.19	13.19– 3.83	.15– .12	.34– .09	1.08– .58	.10– .05	.05– .05	.13– .05
Piedmont:									
Soil	88.57–66.49	7.43–1.55	17.11– 5.76	1.13– .08	.69– .19	3.96– .62	1.53– .16	.17– .05	.15– .04
Subsoil	74.99–44.15	16.23–2.56	27.58–10.90	1.73– .21	1.06– .09	4.07– .61	1.54– .15	.15– .05	.16– .06
Coastal Plain:									
Soil	96.18–76.67	6.05– .41	8.98– 1.37	.40–Tr.	.32–Tr.	.56– .05	.29–Tr.	.09– .04	.23– .02
Subsoil	97.01–62.07	9.43– .33	18.45– 1.19	.38–Tr.	.67–Tr.	.76– .02	.14–Tr.	.10– .03	.13– .03

It should be borne in mind in this connection that soil provinces may include soils derived from very different materials under very diverse climatic conditions, and the number of samples is far too small to permit any but the most general conclusions.

The least variation is found in the Great Plains and Glacial and Loessial provinces, and the greatest in the Piedmont Plateau, and wide variation in potash and soda is usually accompanied by wide variation in lime and magnesia. Phosphoric acid is remarkably uniform in each province, and in the Great Plains with a variation of 0.11 to 0.08, the River Flood Plains 0.06 to 0.05, and the Limestone Valleys 0.19 to 0.15 per cent the variation is not as great as might be obtained in duplicate analyses of the same sample. Therefore, so far as each of these provinces is represented by these samples, they may be said to be uniform in phosphoric-acid content.

VARIATION IN SOILS OF THE SAME TYPE.

In this series of analyses few types are represented by more than one sample, but comparing in some cases sandy loams with fine sandy loams, the variation in major constituents in soils of the same or approximate textures is shown in Table 6:

TABLE 6.—*Variation in chemical composition of samples of the same type or of types of approximate textures.*

Type.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
Memphis silt loam:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	81.13	2.92	8.52	0.31	0.39	1.78	0.52	0.08	0.03
2	80.18	3.05	8.48	.27	.45	1.84	.72	.10	.03
Cahaba fine and very fine sandy loam:									
1	91.39	.97	3.72	.21	.09	.90	.12	.06	.06
2	93.29	.78	2.45	.15	.01	.45	.03	.06	.10
Norfolk sandy and fine sandy loam:									
1	94.50	.83	2.07	.39	.09	.10	.11	.06	.07
2	95.54	.62	1.70	.06	Trace.	.06	.18	.05	.03
3	92.87	1.17	2.75	.03	Trace.	.05	.01	.04	.05
Ruston fine sandy loam:									
1	95.51	.68	1.70	.12	Trace.	.16	.04	.04	.23
2	90.22	1.52	4.26	.06	.01	.12	.14	.05	.04
Susquehanna fine sandy loam:									
1	90.90	3.02	2.59	.11	.09	.28	Trace.	.04	.07
2	91.57	3.00	2.78	.04	.03	.10	Trace.	.09	.08
3	91.17	1.31	3.65	Trace.	Trace.	.12	Trace.	.04	.08

It will be observed that the two samples of Memphis silt loam taken a few miles apart in the same State are so nearly alike in composition that they could very well be considered duplicates of the same sample, and the same is true, perhaps to a less degree, of two samples of Susquehanna fine sandy loam, No. 1 and No. 2, taken in Texas and Mississippi, respectively.

On the other hand, samples No. 2 and No. 3 of Susquehanna fine sandy loam differ considerably in iron and alumina, and the samples

of Ruston fine sandy loam differ markedly in iron, alumina, and sulphur. Still further, on comparison of soils of different types, it is possible to choose two or more that agree quite as closely as any two of the same type. This is brought out in Table 7.

TABLE 7.—*Variation in the chemical composition of soils of the same texture but of different series.*

Type.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Norfolk fine sandy loam	95.54	0.62	1.70	0.06	Trace.	0.06	0.18	0.05	0.03
Ruston fine sandy loam	95.51	.68	1.70	.12	Trace.	.16	.04	.04	.23
Tifton fine sandy loam	94.15	.94	1.67	.05	Trace.	.10	Trace.	.04	.06
Portsmouth fine sandy loam	94.85	.41	1.37	Trace.	Trace.	.06	.06	.05	.03
Memphis silt loam	80.18	3.05	8.48	.27	0.45	1.84	.72	.10	.03
Decatur clay loam	79.35	4.44	8.89	.63	.39	.67	.24	.18	.13
Oswego silt loam	71.38	3.63	12.29	1.09	.36	2.28	1.14	.10	.18
Hagerstown loam	70.99	4.23	11.39	.93	1.08	2.71	.82	.19	.39

Probably no one has ever seriously contemplated classifying soils on the basis of their chemical composition alone, but it seems probable that soils that are alike in color, texture, relation of soil to subsoil, and formed by the same agencies, in other words, having such similar characteristics that they would be given the same type name by field observers, should have some chemical resemblance. The soils just compared, the analyses of which are more or less alike, are soils that because of characteristics other than texture have been given distinct type names; but how wide the variation of a single type may be in chemical composition, or whether some types should be separated into two or more because of chemical differences, or two or more types amalgamated because of chemical resemblances, is a matter for future investigation.

LIMIT OF ERROR IN ANALYTICAL WORK.

Earlier in the paper the authors stated what they considered the limit of error in the analytical work involved in the analyses here presented and discussed. It was stated that what was meant by limit of error was the allowable variation in results obtained from the same sample by two analysts familiar with the method used.

Several factors may contribute to this error: Lack of uniformity of sample, impure reagents, contamination from glassware or other utensils, and, finally, the error incident to the method, which may be of both a personal and chemical nature. All except the last may be nearly eliminated by care and blank determinations.

All analytical results are a compromise, usually arrived at by taking advantage of the solubility of compounds to be removed and the relative insolubility of the compound to be recovered and determined. No compound is absolutely insoluble, and when rela-

tively large quantities of easily soluble compounds have to be washed from a relatively small quantity of a nearly insoluble compound, an appreciable quantity of the latter may be lost before all of the former have been removed. As an example, in the fusion analysis of a soil after removal of the silica there remains an acid solution of all the bases with a large excess of sodium chloride. In the precipitation of calcium as calcium oxalate, it is necessary, of course, to remove this excess of chlorides, and calcium oxalate being slightly soluble, some is lost and may or may not be recovered later in the analysis. The personal factor of judgment comes in at this point and will explain many discrepancies.

The limits of error stated apply to analyses of soils of average composition by the fusion method. It is not meant, for instance, that the limit of error in all CaO determination is 0.10, for in the case of a dilute acid extract of a soil where the only excess of salts introduced is ammonium salts, the error allowed should be much smaller.

One of the reasons for drawing attention to this matter here is the practice in some quarters of publishing soil analyses in terms of pounds per acre. Such results are presumably based on an average of several analyses, but the variations of such analyses usually do not appear.

Assuming that an acre of soil 6 inches deep weighs 1,750,000 pounds, the limits of error stated when calculated to pounds per acre 6 inches deep would be as follows:

CaO limit 0.10 per cent or 1,750 pounds.
K_2O limit 0.05 per cent or 875 pounds.
P_2O_5 limit 0.04 per cent or 700 pounds.

Stated in another way it would appear as follows: Suppose a soil on analysis gave K_2O, 0.50; CaO, 0.30; P_2O_5, 0.08, allowing the above limits of error, the composition might be:

	Per cent.
K_2O	0. 525 or 0. 475
CaO	0. 35 or 0. 25
P_2O_5	0. 10 or 0. 06

Or in pounds per acre:

K_2O	9, 187. 5 or 8, 312. 5
CaO	6, 125 or 4, 375
P_2O_5	1, 750 or 1, 050

It is quite plain then that too much significance should not be attached to differences of a few hundred pounds of any ingredient when the composition of a soil is expressed in pounds per acre, not because the actual presence or absence of such an amount might not have an effect, but because the statement based on chemical analysis may depart that much from the actual fact.

SUMMARY.

In this paper there are presented the complete analyses of 45 samples of soil, representing four soil provinces. These, together with the analyses of 24 samples previously published representing also four provinces, are discussed from the points of view of extreme variation of all the samples, variation in composition within a soil province, variation of the same type, and the bearing of the limit of error in analysis on the interpretation of analytical data.

It is thought that the analyses discussed represent nearly the extremes in composition of soils in the regions in which the samples were taken. Marked resemblances in composition of soils from the same province are pointed out. It is shown that some samples of the same type differ considerably in chemical composition. It is also shown that some soils of different types may resemble each other in chemical composition as closely as different samples of the same type.

It is pointed out that the unavoidable error in analytical operations is in many cases of such magnitude that when analyses are stated in pounds per acre differences of several hundred pounds of some constituents are not significant.

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